

with its lower rungs wanting. How far managers will take advantage of their powers remain to be seen. The changes which are compulsory, such as that which makes drawing universal for boys' schools, will, of course, take effect widely at once. Those which are merely permissive may be slow in their operation. Meanwhile, those who are in earnest about the introduction of such subjects as manual training into elementary schools could not better occupy the time which intervenes before the new Code comes into force, at the end of August next, than in perfecting a graduated scheme of instruction such as may be confidently recommended to school managers to submit to the Education Department.

We have laid stress in this article on the proposed changes in the elementary school curriculum, because, important as these are, they are likely to be overshadowed in the coming discussions on the Code by other questions which appeal more directly to party politicians. We have thus left ourselves no room to do more than allude to other reforms which will affect as powerfully the educational character of our schools as the widening of the course of study. After all, the main guarantee of efficiency is the quality of the teaching staff. The new Code raises the requirements of the Department as to minimum staff, improves the regulations regarding the examination and training of pupil teachers, and provides for the creation (on a very limited scale it is true) of day Training Colleges attached to the Universities or Higher Local Colleges, as well as for the attendance of day students at the existing Training Colleges. The Code further revises the system under which the Parliamentary grant is paid, and almost entirely abolishes payment on results of individual examination. It gives freedom to teachers to classify their scholars as they please, so that a child may be in three different standards in the three R's, and in two different standards again in the two class subjects. All these and other changes, which demand much more notice than we can give them, make the Minute of the Department which has just seen the light emphatically a "Teachers' Code."

THE CAVE FAUNA OF NORTH AMERICA.

The Cave Fauna of North America, with Remarks on the Anatomy of the Brain and Origin of the Blind Species. By A. S. Packard. Pp. 1-156, with 27 Plates.

THIS important memoir is the first of vol. iv. of the "Memoirs of the National Academy of Sciences," and contains the results of an examination of the Mammoth Caves in Kentucky made during the months of April and May 1874, and of some other caves in Indiana and Virginia which were visited by the author at a later date.

A description of eighteen caves, with notes on their hydrography and geological age, and an account of the fauna of those which are better known, form the first section of the memoir. The caves form the natural drains of the country, all the surface drainage being at once carried down into them through the innumerable "sink-holes" which pierce the thin stratum overlying the Carboniferous Limestone, in which the caves are excavated. The Mammoth Cave is the largest and best known, with

its 150 miles of passages and avenues, frequently crossing one another at different levels.

Their geological age is uncertain, but there is very little doubt but that they assumed their present proportions long after the melting of the glacial ice and are coæval with the Niagara river-gorge. And as the caves must have been incapable of supporting life while flooded, their preglacial fauna, if they had one, must have been killed off, and they could not have become ready for their present fauna until comparatively recent times; therefore, they must have been colonized by members of the existing fauna. The mode of colonization is very simple. Tracks of bears, wolves, and smaller animals occur in nearly all those caves which are easily accessible from without, and clinging to the skins of these animals various small Arthropods may have been carried in; other species of insects and Myriopods which naturally lead a subterranean life may voluntarily enter the fissures and sink-holes which abound in this region; others, again, get carried in by the agency of torrents which flow in during certain seasons of the year, as, for instance, the eyed fishes and species of Crustacea which abound in the surface waters.

That cave animals have entered the caves from without is further corroborated by the fact that in the case of very many cave species closely allied outdoor species are found in great numbers in the immediate vicinity of the caves. Also caves situated near one another are populated by a similar fauna, which allows us to classify them in groups closely corresponding to the various zoo-geographical regions of the country.

The author then proceeds to the systematic detailed description of the fauna, a section which constitutes more than one-third of the memoir. As in the case of the fauna of the outside world, the species of Arthropoda form a very large percentage of the total number of cave species; but, however different the groups to which the various species belong may be, they possess the common characteristics of slenderness of body and appendages and of the absence of functional eyes. The systematic description is followed by lists of all the North American and European cave species known at present, showing that the European species are by far the most numerous. It is therefore argued that the European caves have been inhabited for a longer period than the American.

Although the animal kingdom, at any rate as far as certain groups are concerned, is comparatively well represented, vegetable life is almost absent, evidently owing to the dryness and the absence of light; in fact, so far as is known at present, it is only represented by a few Fungi and two or three Moulds. The air must also be comparatively free from the germs of bacteria of putrefaction, as the decay of organic refuse is very slow, and meat hung up in the cave will keep a long time. But though bacteria are absent, their office is performed by larvæ of the blind beetle (*Adelops hirtus*) and of flies.

Cave animals are mostly carnivorous. The blind fish (*Amblyopsis*) lives on Crustacea, and especially on the blind crayfish, which in its turn preys upon living *Cæcidotea*, but how they and other small aquatic Crustaceans maintain an existence is unknown. The Myriopods, which are very common, feed on decayed wood and fungous growths.

However, in all cases, as a rule, food must be very

scanty, and "lack of food as well as the absence of light was one of the factors concerned in the diminution of size and in the slenderness of blind cave animals as compared with their lucicolous allies."

The effect of total darkness upon animals is twofold. Firstly, colour is either entirely or partially bleached, and, secondly, the sense of sight is lost. Eyesight may be lost in various ways. Either the optic lobes and nerves may atrophy, while the retina, pigment, and lens remain more or less persistent; or the optic lobes and nerves may persist, while the retina and eye-facets atrophy; or, again, the whole of the optic apparatus may atrophy. Examples of all these cases are given in the important chapter which is devoted to a description of the anatomy of the brain and eyes of certain blind Arthropods, and illustrated by numerous drawings of sections through various regions of the head.

It is argued that this atrophy must be comparatively sudden and wholesale, because no series of individuals has been found with the optic lobes or nerves in different stages of disappearance. Transitional forms have been observed with eyes with a varying number of crystalline lenses, as in the case of *Chthonius*; those individuals which live near the mouth of the cave have better developed eyes than those which live far in. And surely, on further examination, more transitional forms will be discovered, as animals must be continually getting into the caves from the outside; their descendants becoming gradually adapted for cave life, until they finally reach the degree of modification of the present older occupants.

As the sense of sight diminishes, it is compensated by an increase of the delicacy of other senses. The tactile and olfactory senses are rendered more sensitive, the appendages become much more slender, and the blind form is altogether more timid and cautious than its eyed allies, as has been particularly noticed in the blind crayfish.

The last part of this memoir deals with what is of most general interest to the biologist, viz. the bearing of these facts upon the theories of evolution. The author states that here the term "natural selection" expresses the result of a series of causes rather than any one cause in itself. The most important of these causes are: the *change of environment*, from light to partial or total darkness, involving diminution of food, the disuse and loss of certain organs, with compensation as has been mentioned above; *adaptation*, enabling the more plastic forms to survive and perpetuate the stock; *heredity*, which operates to secure the future permanence of the newly originated forms—the longer it acts, the earlier will the inherited characters appear in the development of the animal; and, lastly, *isolation*, which, after adaptation and heredity have established the typical characters, prevents intercrossing with out-door forms, and thus insures the permanence of these characters.

The author adduces facts which seem to prove that the organic adaptations to a life in darkness may have been induced after but a few generations, perhaps one or two only, resulting in the comparatively rapid evolution of cave species. If that be the case, then, there is no reason why they should not be produced artificially, but at present no experiments have been made to prove the mutual convertibility of cave species and their lucicolous

allies. If a cave species could be made to revert to an epigeal form by keeping it for a number of generations in a gradually increasing amount of light; and if, on the other hand, a lucicolous species could be changed into a cave form by a converse process, the theory of occasional rapid evolution due to sudden changes in the environment would receive its final proof.

Mr. Packard draws attention to the interesting parallel between the life of the abysses of oceans and lakes and that of caves. In both cases vegetable life is almost absent, and a large proportion of the animal forms have become similarly modified with regard to the degeneration of the optic organs and corresponding development of other organs as compensation. But while caves have only been populated comparatively recently, the ocean abysses have had inhabitants for a very much longer time, and consequently these have had time to become much more highly specialized than the inhabitants of caves.

This most valuable contribution terminates with a bibliography containing the titles of previous publications on the subject, and we must not omit to mention that in a separate chapter a list is given of the known non-cavernicolous blind animals. As far as the higher classes are concerned, this list contains about the same number of species as the one of the blind cave-dwelling forms.

R. T. G.

LINEAR DIFFERENTIAL EQUATIONS.

A Treatise on Linear Differential Equations. By Thomas Craig, Ph.D. Vol. I. Equations with Uniform Coefficients. (New York: John Wiley and Sons, 1889.)

TREATISES on this subject have been somewhat numerous of late. We recently noticed in these columns an excellent, but fairly elementary work, "On Ordinary and Partial Differential Equations," by Prof. Woolsey Johnson. The student who wishes to enter on the profitable perusal of the book before us must be well versed in all the ordinary modes of procedure,¹ and then he will find that Dr. Craig is well qualified to lead him through the intricate windings of this difficult branch of mathematics. The advanced student will find the author's analyses of use to him whilst reading the various original memoirs here introduced to him, for the first time, in English. Some may remember that Mr. Forsyth, in his classical treatise, omitted the investigations of Fuchs, the recent researches of Hermite and Halphen, contented himself with a slight sketch of Jacobi's method for partial differential equations, and did not at all touch upon the methods of Cauchy, Lie, and Mayer. The consideration of these matters he reserved for a future volume.

The theory of the subject before us, i.e. of linear differential equations, almost owes its origin, in Dr. Craig's opinion, to two memoirs by Fuchs, published in vols. lxvi. and lxviii. of *Crelle's Journal* (1866, 1868):—

"Previous to this the only class of linear differential equations for which a general method of integration was known, was the class of equations with constant coefficients, including, of course, Legendre's well-known equation, which is immediately transformable into one with

¹ "The reader is of course supposed to be familiar with the ordinary elementary theory of differential equations" (p. 32).